Recent U.S. Research in Global Environmental Change

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Outline

- Defining “global change”
- Four Categories of Interacting Changes
- Accomplishments, in Six categories
- NIGEC
- AmeriFlux
- Acknowledgements

Defining "Global Change"

The Global Change Research Act defines global change as "*changes in the global environment (including alterations in climate, land productivity, oceans or other water resources, atmospheric chemistry, and ecological systems) that may alter the capacity of the Earth to sustain life.*"

Climate Change Studied in Four Categories of Interacting Changes:

1. Changes in the natural and human-induced forces affecting the Earth system including solar variability, atmospheric composition, land-use cover variability, human population variability, and technological choices.

2. Changes and variability in Earth system attributes such as temperature, precipitation, climate oscillations and modes (i.e., ENSO), extreme weather events, and sea levels that directly effect natural and human activities.

Categories of Interacting Changes (cont):

3. Changes in ecosystems, both managed and unmanaged, and the ability of these ecosystems to adapt to change.

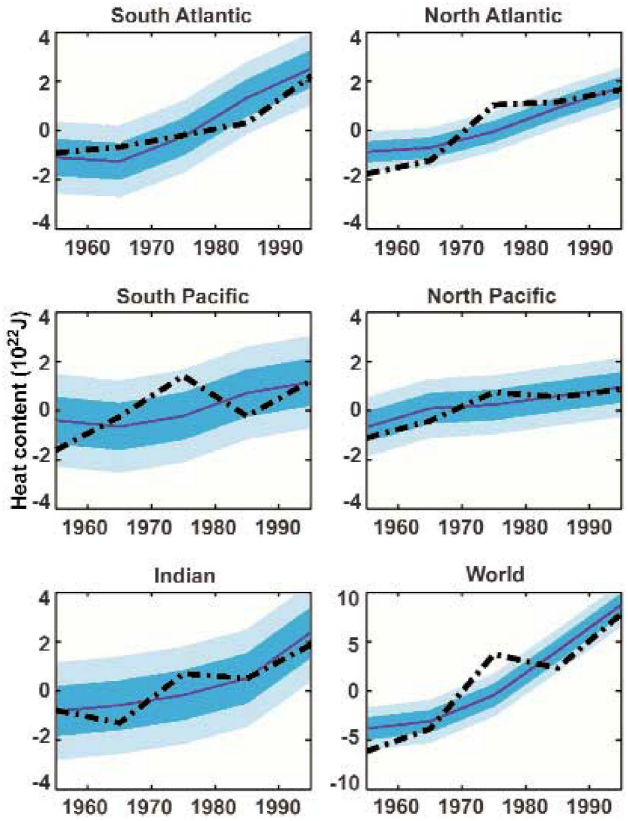
4. Changes in human communities, organizations, societies, and economies triggered by 1-3.

Recent Research Accomplishments

Recent U.S. climate change research accomplishments can be described in six categories:

1. Climate Variability and Change
2. Atmospheric Composition
3. Global Carbon Cycle
4. Global Water Cycle
5. Changes in Ecosystems
6. Human Dimensions of Climate Change

1. Climate Variability and Change



Ocean Warming Since the 1950s

(Barnett, et al. Science, 13 April 01)

- Climate models were used to simulate two observed global warming periods during the past century, one from 1925-44 and another from 1978 to the present.
- Confirmed a warming trend, with a decadal variability, since the 1950s for the upper 3000m of the Earth's oceans.
- Demonstrated, that this observed ocean warming trend is what would be expected given the observed increase in greenhouse gases and aerosols in the atmosphere.

• Climate Variability and Change (cont)

- Deployed Global Lake Drilling System (GLAD 800) to Lake Titicaca in Boliva/Peru in order to recover a 500,000 year record of atmospheric dynamics for this region.
- Identified an enhanced rate of heating of the North Hemisphere tropical oceans.
- Collected accurate and systematic satellites measurements of solar variability, using data from ACRIMSAT (launched Dec 99).

1. Climate Variability and Change (cont)

- Initiated deployment of Argo array of profiling floats in global oceans for long term profiling of temperatures, currents and salinity.

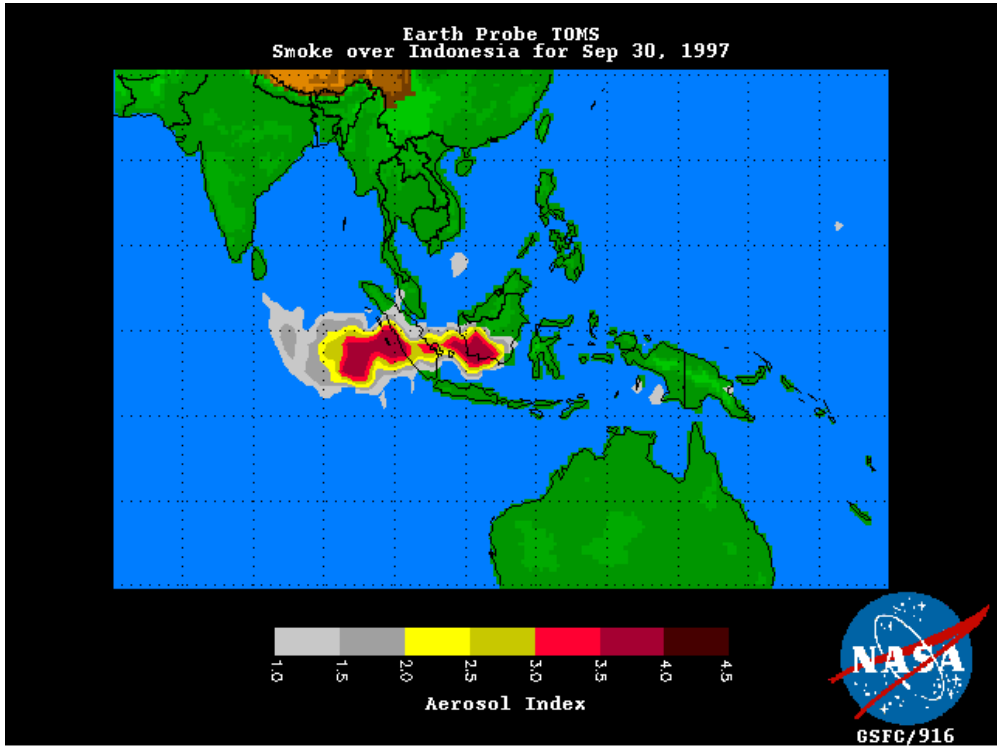
- Recovered unprecedented record of temperature variability from a Himalayan glacier, showing that the last 50 years were warmer than any period for the last 1,000 years.

Example of an Argo array float

2. Atmospheric Composition

- Observations showed a decline in the total abundance of chlorine compounds in the stratosphere, adding credence to the model calculations used to project future changes in atmospheric chemistry.

- Demonstrated how short-term variability in global climate can combine with fires related to forest-clearing activity to produce massive air pollution over a wide area, such as the buildup of pollution in Southeast Asia during the last El Niño event, during September 1997.



2. Atmospheric Composition (cont)

- Showed a strong historical relationship between late-wintertime minimum temperatures and stratospheric ozone depletion in the Arctic region (colder temperatures are associated with greater ozone depletion).

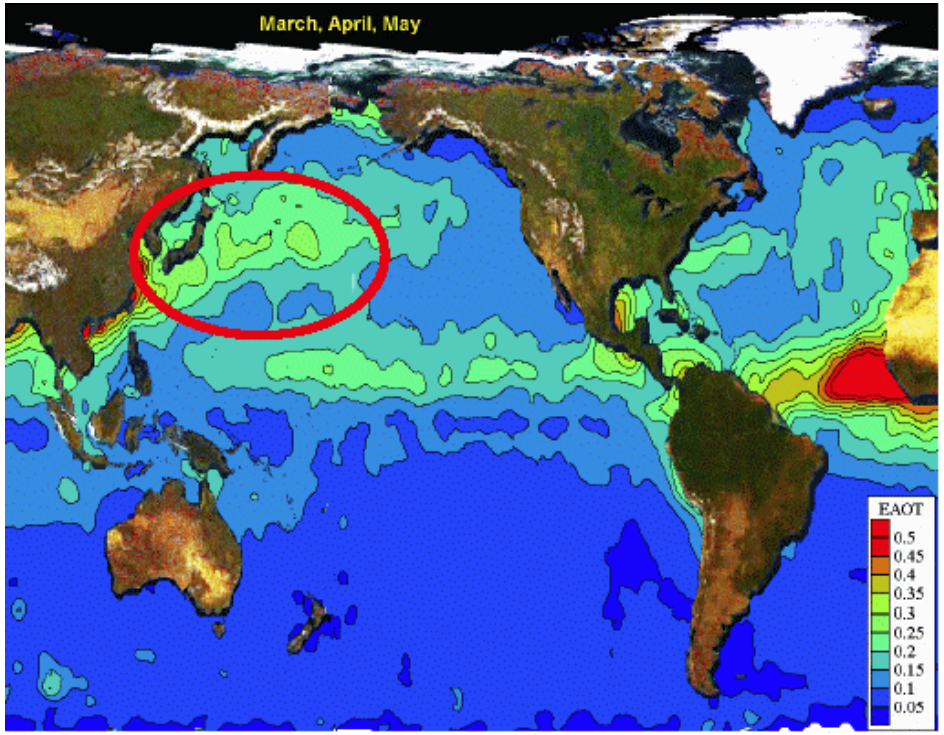
- Recent measurements add support to the hypothesis that the Arctic springtime will show individual years of substantial depletion of the ozone layer, even as the trend of increasing atmospheric concentrations of chlorine is reversed.

- Developed an improved set of atmospheric transport and chemistry models that assimilate satellite observations in real time and include descriptions of atmospheric aerosols and their transport in order to determine their radiative impact.

2. Atmospheric Composition (cont)

- Successfully completed the Aerosol Characterization Experiment-Asia (ACEAsia) in spring 2001.

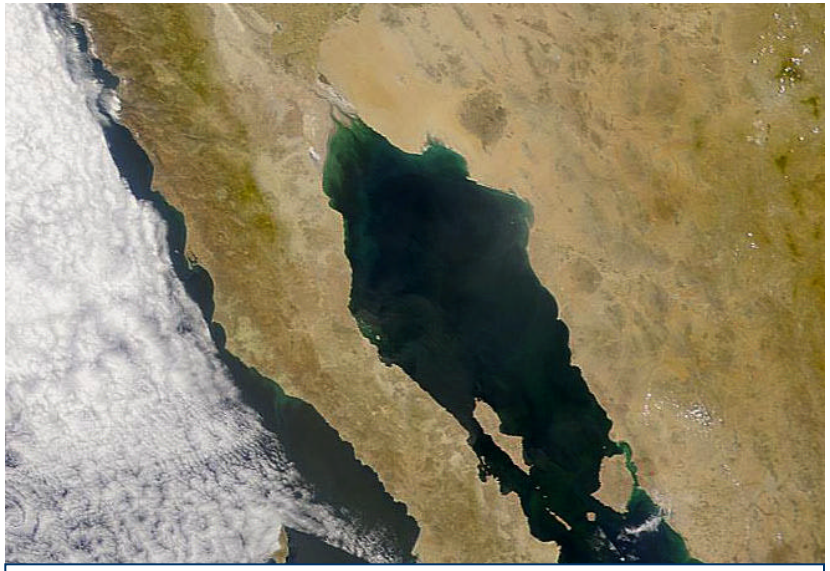
- Quantitatively evaluated the relative importance of seasonally and geographically varying processes that affect the production and fate of oxidants for several metropolitan areas in the United States.



Area profiled during the ACEAsia (circled in red)

3. Global Carbon Cycle

- The SeaWiFS satellite instrument marked its third year of continued remote-sensing measurements of ocean color, an indicator of certain species including Phytoplankton, a major processor of carbon in the upper ocean. An instrument aboard the EOS Terra satellite also began producing a wide array of data products on marine ecosystems.



Taken 3 June 2002 of the North Pacific Ocean just off the west coast of Mexico's Baja Peninsula. The green color of the water in the Gulf of California reveals the presence of chlorophyll- bearing phytoplankton. (Courtesy of NASA)

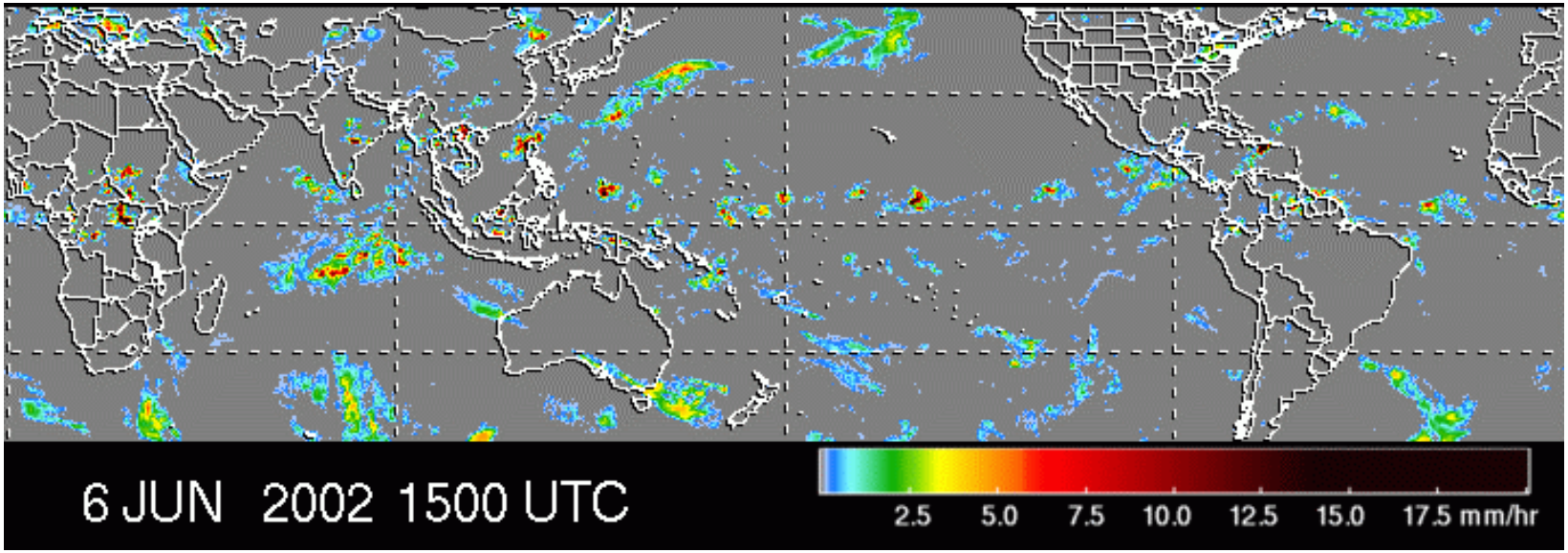
3. Global Carbon Cycle (cont)

- Carbon uptake across a range of latitudes was determined for North American and European ecosystems. The varying rates of carbon storage suggest that, at a given latitude, higher temperatures promote greater carbon uptake.

- Early results in the ongoing Large-Scale Biosphere-Atmosphere Experiment in Amazonia indicate significant complexity of the carbon cycle in Amazonia.

4. Global Water Cycle

- Developed a greatly improved global tropical rainfall climatology using almost four years of rainfall measurements by the Tropical Rainfall Measuring Mission (TRMM) and other surface based observations



An Example of TRMM Data. Recent 3 Hour global rainfall (courtesy NASA).

4. Global Water Cycle (cont)

- Completed the first year of analysis of global measurements of the radiative properties of clouds and aerosols taken by EOS Terra. These observations will reduce uncertainty in the determination of cloud/aerosol radiative forcing and feedback processes involved in the heating and cooling of the Earth's surface and atmosphere.

- Developed improved representations for modeling of the land surface, including topographic variability, soil physics, and snowpack physics.

- Completed the second precisely controlled mapping of most of Antarctica in a mode that will enable the calculation of surface flow rates.

4. Global Water Cycle (cont)

- Provided the means for accurate, continuous measurements of water vapor vertical profiles from field campaigns at one of the Atmospheric Radiation Measurement (ARM) program sites.

- Differentiated the chemical characteristics in spring snow melt between cool morning periods and warmer periods later in the day.

4. Global Water Cycle (cont)

- High-resolution data from LANDSAT-7 and EOS Terra showed the early beginnings of a crack in an Antarctic ice flow. The crack, found to be 25 km long and 400-500 meters wide in January 2001, was growing at about 13 meters a day. This is the first observation of the beginning of the formation of massive icebergs.

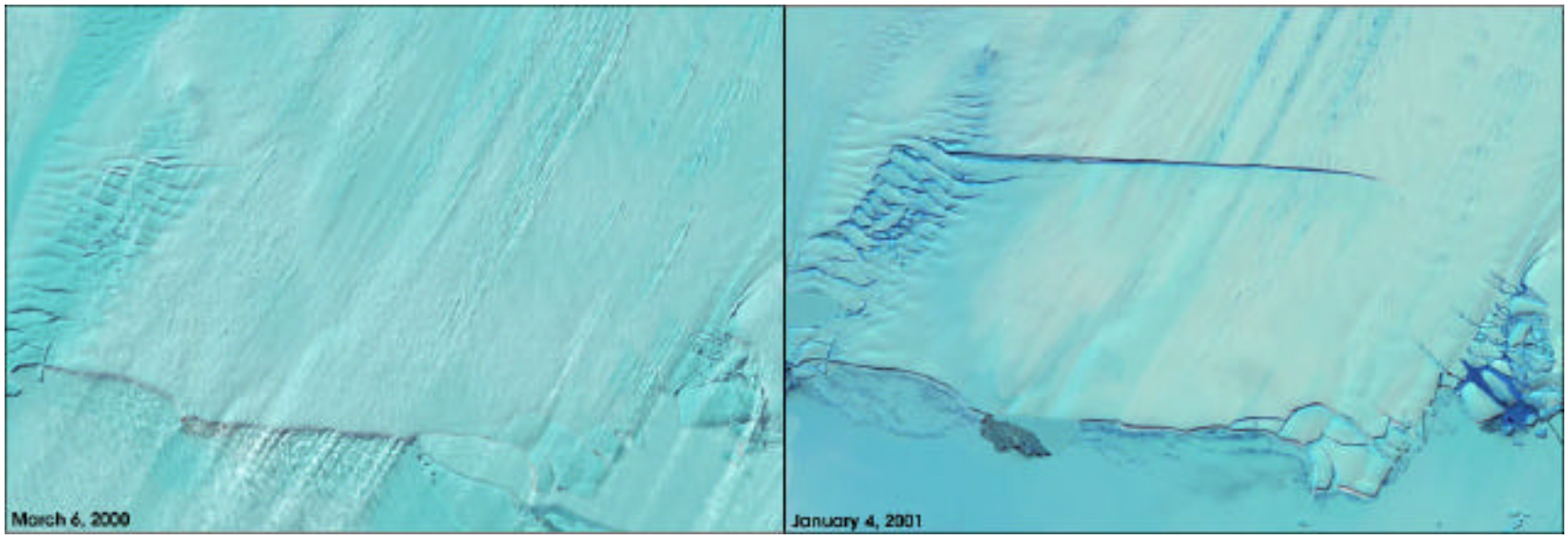


Image courtesy of NASA

5. Changes in Ecosystems

- Field studies with controlled, elevated CO_2 levels indicated that growth stimulation of a few invasive plant species in the arid U.S. Southwest was stronger than growth stimulation in native species.

- Mixed findings in crop studies using elevated CO_2 have highlighted the uncertainties in projecting crop and forest productivity as CO_2 and climate change, because energy production from fossil fuel combustion causes an increase in both tropospheric CO_2 and ozone, and at comparable relative rates.

- After eight years of experimental manipulation of precipitation received by a forest, it was discovered that large trees were relatively insensitive to chronic changes in precipitation. These results require revisions of many models used to predict effects of climatic change on forests

5. Changes in Ecosystems (cont)

- Synthesis of results from the Boreal Ecosystem-Atmosphere Study (BOREAS) and other research programs in North American boreal and Arctic ecosystems have demonstrated that high-latitude ecosystems play a major role in the climate system. Average temperature and precipitation in these regions have increased, but changes in soil moisture remain uncertain.

6. Human Dimensions of Global Change

- EPA and NOAA have established ongoing regional research and assessment projects in six regions across the United States to study the effects of climate variability and change on natural and human systems.

- Analyses are showing that significant reductions in the projected cost of mitigating greenhouse gas emissions can be achieved by reducing emissions of greenhouse gases other than carbon dioxide.

National Institute for Global Environmental Change (NIGEC)

The Six NIGEC Regions

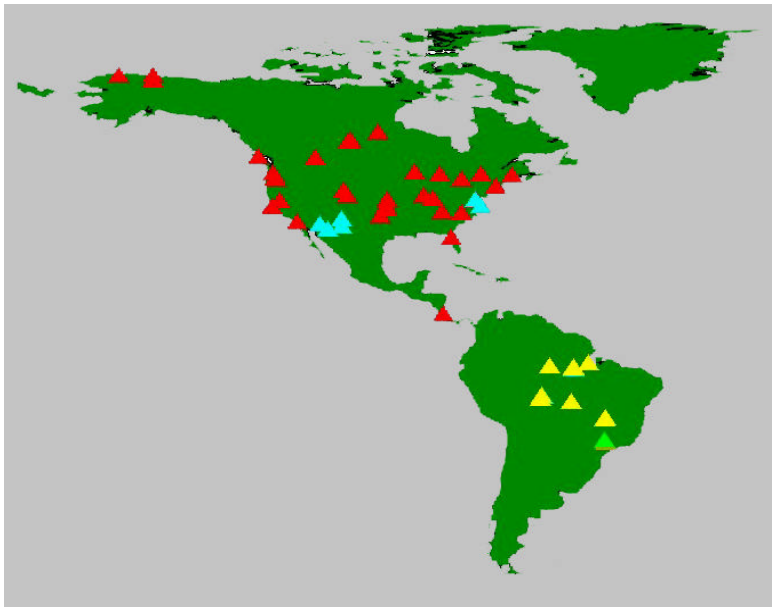
NIGEC is a university-based, virtual institute conducting research to:

- Increase understanding of the net carbon exchange by U.S. ecosystems
- Increase understanding of the ecological effects of climate change and the processes involved
- Determine the impact of climate change on social, biological, and physical ecosystems.

The AmeriFlux Network

In 1996 NIGEC started the AmeriFlux network of sites with thirteen sites constituting the original network. Since then it has expanded to over 40 sites with all the major biomes being represented.

Original AmeriFlux Sites



Current AmeriFlux Sites

AmeriFlux Network (cont)

Each AmeriFlux site measures both above and below ground properties that contribute to ecosystem growth. The intent of the network is to focus on identifying which combinations of forcing factors are most important to the future of ecosystem growth in a ever more perturbed “global warming” world.

Typical flux information would consist of multiple-year half-hour averaged data on:

- Carbon dioxide, water vapor, sensible heat and momentum flux densities measured at a certain height above and within the canopy.
- Air temperature and humidity measured above and within the canopy
- CO_2 profiles measured above and within the canopy.
- Soil temperature measured at certain distances above the soils.
- Net radiation, PAR and solar radiation (direct and diffuse) measured above the canopy.
- PAR measured below the canopy at 1m along a 20 m transect.
- Precipitation and soil moisture.
- Some AmeriFlux sites are involved in specialized process studies.

Acknowledgements

For more information visit:

http://nigec.ucdavis.edu